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Research

Control of Quackgrass (*Elytrigia repens*) and Broadleaf Weeds and Response of Potato (*Solanum tuberosum*) Cultivars to Rimsulfuron[1]

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Abstract: Studies were conducted from 1992 to 1995 to determine the effect of rimsulfuron on corn spurry, wild radish, narrowleaf goldenrod, and quackgrass and potato cultivars. Rimsulfuron alone gave 100% control of wild radish, 68 to 70% control of corn spurry, and 75 to 90% control of narrowleaf goldenrod. Rimsulfuron plus metribuzin gave 99 to 100% control of wild radish and 85 to 100% control of corn spurry. Quackgrass control varied from 51 to 90% between experiments, indicating that environmental and plant factors affected the activity of the herbicide. Tank mixes with metribuzin slightly reduced the control of quackgrass but resulted in greater foliar injury than that of rimsulfuron to potato. Slight injury to potato plants disappeared within 2 to 3 wk, and tuber yields were not reduced. Russet Burbank, Shepody, and Kennebec potato cultivars had slight (2 to 8%) injury from rimsulfuron. Injury to Shepody (14 to 20%) and Russet Burbank (11%) increased when rimsulfuron was applied with metribuzin. Rimsulfuron had no effect on the number or the fresh weight of sprouts on daughter tubers tested the next spring after application.

Nomenclature: Metribuzin; rimsulfuron; corn spurry, *Spergula arvensis* L. #[3] SPRAR; narrowleaf goldenrod, *Solidago canadensis* L. # SOLCA; quackgrass, *Elytrigia repens* Nevski # AGRRE; wild radish, *Raphanus raphanistrum* L. # RAPRA; potato, *Solanum tuberosum* L. # SOLTU 'Russet Burbank', 'Shepody', 'Kennebec'.

Additional index words: Daughter tuber sprouting, DPX E-9636.

Abbreviations: GC, ground crack; lf, leaf; PEI, Prince Edward Island; POST, postemergence; PRE, preemergence; RH, relative humidity.

INTRODUCTION

Approximately 44,000 ha of potato are produced for processing use, for table use, and for seed on Prince Edward Island (PEI) in Eastern Canada, each year. Quackgrass is a problem perennial weed that infests fields on PEI and in other potato production areas, resulting in crop losses because of competition (Ivany 1986). Several herbicides that give quackgrass control in potato are available (Ivany 1984, 1986, 1988, 1991), but none of these herbicides controls broadleaf weeds. Rimsulfuron has shown excellent control of several broadleaf weeds (Ackley et al. 1996a, 1996b; Blackshaw et al. 1995; Eberlein et al. 1994; Guttieri and Eberlein 1997; Renner and Powell 1998; Robinson et al. 1996). The response of several potato cultivars to rimsulfuron has been evaluated (Blackshaw et al. 1995; Robinson et al. 1996), and either the cultivars were not affected by rimsulfuron at registered use rates or injury was transitory and potato yield unaffected. The objectives of this research were to determine the effect of rimsulfuron, alone and with metribuzin, on quackgrass, broadleaf weeds, and potato cultivar yield and daughter tuber sprouting.

MATERIALS AND METHODS

Weed Control Experiments—General. Studies were conducted from 1992 to 1995 on a Charlottetown fine sandy loam soil (Orthic Humo-Ferric Podzol), with pH 5.5 to 6.1. Study sites had a quackgrass infestation of 50 to 100 shoots/m^2 and a natural, heavy infestation of corn spurry and wild radish. Each experiment was conducted for 2 or 3 yr. The first experiment was conducted in 1992, 1993, and 1994 to evaluate rimsulfuron alone at 15 and 25 g/ha, sequentially after 180 or 300 g/ha of metribuzin preemergence (PRE), or tank mixed with me-

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

tribuzin postemergence (POST). Potato seed pieces were planted on May 22, 29, and 20 and harvested on October 16, 4, and 14 in 1992, 1993, and 1994, respectively. Herbicides were applied PRE on June 1, 9, and 2 and POST on June 23, July 7, and June 27 in 1992, 1993, and 1994, respectively. The second experiment was conducted in 1994 and 1995 to determine the effect of metribuzin at 120, 180, or 300 g/ha with rimsulfuron at 15 g/ha POST on potato injury and control of quackgrass, corn spurry, and wild radish. Metribuzin at 120, 180, 300, and 420 g/ha POST alone was included for comparison. Potato seed pieces were planted on May 20 and 24 and harvested on October 14 and 10 in 1994 and 1995, respectively. Herbicides were applied PRE on June 4 and 2 and POST on June 27 and 22 in 1994 and 1995, respectively. The third experiment was conducted at one site in 1993 and one site in 1995 to evaluate narrowleaf goldenrod control with several herbicides including rimsulfuron. Potato seed pieces were planted on May 29 and 24 and harvested on October 4 and 10 in 1993 and 1995, respectively. Herbicides were applied PRE on June 9 and 2, just before potato emergence on June 21 and 13, and POST on June 30 and 22, in 1993 and 1995, respectively. The sites had a low to moderate infestation of narrowleaf goldenrod and 50 to 75 shoots/m^2 of quackgrass. In all experiments, Russet Burbank potato was planted at 38-cm spacing in-row. Treatments were replicated four times in a randomized complete block design. Plots were one row 0.9 m wide by 6 m long with a shared guard row on each side. Fertilizer was banded at planting at 130, 57, and 109 kg/ha of N, P, and K, respectively. With the exception of herbicide treatments, cultural practices were the same as those recommended for commercial production. Herbicides were applied with a tractor-mounted, small-plot sprayer that delivered 200 L/ha spray volume at 275 kPa pressure, using a 8003 flat-fan spray tip. A nonionic surfactant[4] was used in all rimsulfuron treatments at 0.2% (v/v) of the spray solution. Preemergence treatments were made within 5 d of planting, and POST treatments were made to four-leaf quackgrass and two- to four-leaf broadleaf weeds (except for 5- to 10-leaf narrowleaf goldenrod), when potato was 12 to 20 cm tall.

Weed control was rated visually at 3 wk after herbicide application, using a linear scale of 0 to 100, where 0 = no control and 100 = complete kill. Narrowleaf goldenrod plants per 6-m plot row were counted on August 5 and 23 in 1993 and 1995, respectively. Potato injury was rated visually at 1 and 3 wk after rimsulfuron treatment, using a linear scale of 0 to 100, where 0 = no injury, and 100 = crop death. All plots were hilled mechanically 3 to 4 wk after the last herbicide treatment was applied and before row closure. At maturity, the entire plot row was harvested using a one-row mechanical harvester, and graded mechanically to obtain tuber marketable and total yield. Tuber specific gravity was determined using the weight in air and water method.

Cultivar Response to Rimsulfuron. Experiments were conducted in 1994 and 1995 to determine the response of Russet Burbank, Shepody, and Kennebec potato cultivars to rimsulfuron POST, alone or with metribuzin. Potato was planted on May 25 of both years, and harvested on October 19 and 20 in 1994 and 1995, respectively. Russet Burbank was planted at 38 cm, Shepody at 30 cm, and Kennebec at 25 cm in-row spacing. Rimsulfuron was applied at 15 g/ha (registered rate) and 30 g/ha either alone or with 250 or 500 g/ha metribuzin. Metribuzin at 250 and 500 g/ha POST alone or 500 g/ha PRE was also applied as control treatments that most growers commonly use. Herbicides were applied PRE on June 4 and 6 and POST on July 7 and 4, in 1994 and 1995, respectively. Other management practices were the same as noted earlier for the weed control experiments.

Samples of daughter tubers were retained from each treatment and stored over winter at 3 C and 95% relative humidity (RH), and seed germination was determined in March to April the following year. Tubers (25 per plot), ranging from 150- to 250-g weight, were placed stem end down in a rack and placed in a dark growth cabinet set at 20 C and 90 to 95% RH. After 28 d in the growth chamber, the total number of sprouts per tuber and the sprout fresh weight per tuber were recorded.

In all the experiments, data for weed control, crop injury, and yield were analyzed by year and combined across years, and when there were no differences in responses or significant interactions between years, a combined year analysis of the data was presented. Data for quackgrass control are presented for each year as differences in control were noted between years. Data for narrowleaf goldenrod plants per square meter are presented for each year as differences in stand counts were noted between years.

RESULTS AND DISCUSSION

Weed Control Experiments. In the first experiment, rimsulfuron alone or with metribuzin provided 99 to 100% control of wild radish (Table 1). Rimsulfuron used

[4] Agral 90®, 90% nonylphenoxy polyethoxy ethanol, Zeneca Agro, 400 Jones Road, Stoney Creek, Ontario, Canada L8G 3Z1.

Table 1. Effect of rimsulfuron applied alone, sequentially with metribuzin, or when mixed with metribuzin on wild radish, corn spurry, and quackgrass control, on potato injury, and on potato marketable yield (means of 3 yr, except quackgrass).

Herbicide	Rate	Timing[a]	Weed control					Potato injury	Potato marketable yield
			Wild radish	Corn spurry	Quackgrass				
					1992	1993	1994		
	g/ha		%						kg/ha
Rimsulfuron[b]	15	four-1f	100	68	78	70	53	1	40,770
Rimsulfuron	25	four-1f	100	70	81	66	63	1	41,550
Rimsulfuron	15	four-1f	100	85	78	76	55	3	41,620
+ metribuzin	180	four-1f							
Rimsulfuron	15	four-1f	100	94	78	75	58	4	41,420
+ metribuzin	300	four-1f							
Rimsulfuron	25	four-1f	99	87	78	84	68	2	43,610
+ metribuzin	180	four-1f							
Rimsulfuron	25	four-1f	100	97	80	81	65	4	41,890
+ metribuzin	300	four-1f							
Metribuzin	180	PRE	99	99	84	74	55	0	41,340
+ rimsulfuron	15	four-1f							
Metribuzin	180	PRE	100	100	84	76	65	0	41,240
+ rimsulfuron	25	four-1f							
Metribuzin	300	PRE	99	99	81	83	63	2	42,080
+ rimsulfuron	15	four-1f							
Metribuzin	300	PRE	100	100	89	76	66	1	42,640
+ rimsulfuron	25	four-1f							
Nontreated	—		0	0	0	0	0	0	35,810
LSD (P = 0.05)			8	5	2	7	10	2	NS

[a] Abbreviations: lf, leaf; PRE, preemergence.

[b] Nonionic surfactant (0.2% v/v) added to all rimsulfuron treatments.

alone at either 15 or 25 g/ha gave only 68 to 70% control of corn spurry. However, when rimsulfuron was applied with metribuzin as a tank mix or sequentially, control was increased to over 85%. Metribuzin at 180 or 300 g/ha PRE followed by rimsulfuron POST at 15 g/ha gave greater or equal corn spurry control when compared with a tank mix of the two herbicides.

Rimsulfuron, used alone or with metribuzin, provided equal to or greater than 78 and 66% control of quackgrass in 1992 and 1993 (Table 1), but in 1994 control ranged from 53 to 68%. Metribuzin at 180 g/ha PRE followed by rimsulfuron POST at 15 g/ha, or metribuzin at 300 g/ha followed by rimsulfuron at 25 g/ha, gave greater quackgrass control when compared with a tank mix of the two herbicides in 1992, but not in the other years. Control of volunteer oats (*Avena sativa* L.) was also reduced with tank mixes of rimsulfuron and metribuzin applied POST (Eberlein et al. 1994). The lower control achieved in 1994 is believed to have been caused by a combination of abnormal temperatures above 25.5 C for 6 d and less than half the usual rainfall for the 14 d after herbicide application. Slight foliar injury to potato was noted with rimsulfuron alone or with metribuzin, but there was no detrimental effect on potato marketable yield (Table 1). Tuber specific gravity was not affected by any treatment (data not shown). Sequential application of metribuzin and rimsulfuron gave less foliar injury when compared with a tank mix of the two herbicides.

In the second experiment, rimsulfuron applied sequentially after metribuzin or with metribuzin gave 99 to 100% control of wild radish (Table 2). Tank-mixing metribuzin with rimsulfuron, however, reduced control of corn spurry compared with using the herbicides sequentially, except with the higher rate of metribuzin. Metribuzin alone at 120 and 180 g/ha did not control wild radish and corn spurry, but good to excellent control resulted from metribuzin at 300 or 420 g/ha.

Rimsulfuron used sequentially after metribuzin provided only 69 to 76% control of quackgrass in 1994, but in 1995 over 90% control was obtained (Table 2). Rimsulfuron at 15 g/ha, tank mixed with metribuzin, gave 51 to 60% quackgrass control, which was below that obtained with the sequential treatments in 1994. Metribuzin at 120, 180, or 300 g/ha plus rimsulfuron at 15 g/ha POST in 1995 gave 82 to 86% control of quackgrass. Quackgrass control with the tank mix was less than that obtained with the sequential treatment. As noted earlier, lower quackgrass control in 1994 is believed to have been caused by quackgrass being stressed by abnormally high temperatures prior to application and 2 wk of dry weather after herbicide application.

Slight foliar injury to potato was noted at 1 wk after application with all the treatments, but there was no dif-

Table 2. Wild radish, corn spurry, and quackgrass control, potato injury, and potato yield with rimsulfuron used separately or when mixed with metribuzin (means of 2 yr, except quackgrass).

Treatment	Rate	Timing[a]	Weed control				Potato marketable yield
			Wild radish	Corn spurry	Quackgrass 1994	Quackgrass 1995	
	g/ha		%				kg/ha
Metribuzin	420	PRE	100	100	69	90	37,680
+ rimsulfuron[b]	15	four-lf					
Metribuzin	420	PRE	100	100	76	92	37,620
+ rimsulfuron	30	four-lf					
Rimsulfuron	15	four-lf	99	83	60	85	38,350
Rimsulfuron	15	four-lf	99	84	57	82	34,520
+ metribuzin	120	four-lf					
Rimsulfuron	15	four-lf	98	82	51	86	36,370
+ metribuzin	180	four-lf					
Rimsulfuron	15	four-lf	98	94	57	85	34,200
+ metribuzin	300	four-lf					
Metribuzin	120	four-lf	45	26	0	0	25,330
Metribuzin	180	four-lf	52	52	0	0	27,380
Metribuzin	300	four-lf	81	85	0	0	26,790
Metribuzin	420	four-lf	87	92	0	0	27,830
Nontreated	—	—	0	0	0	0	16,480
LSD (p = 0.05)			8	8	8	5	3,400

[a] Abbreviations: lf, lead; PRE; preemergence.

[b] Nonionic surfactant (0.2%, v/v) added to all rimsulfuron treatments.

ference in foliar injury at 3 wk after application (data not shown). Potato marketable yield was not affected by rimsulfuron or metribuzin sequentially, but yield was less with the tank mixes at 15 plus 120 and 15 plus 300 g/ha (Table 2). This injury appears to be an anomaly as yield with 15 plus 180 g/ha was not affected, and in all treatments weed control was comparable for all three weed species. Marketable yield was reduced by metribuzin alone at all rates compared with the combination treatments, most likely because it did not control quackgrass. Tuber specific gravity was not affected by any of the treatments (data not shown).

Goldenrod plant stand in 1993 and 1995 was quite variable, but data do provide useful comparisons for the control of this species. In 1993, neither metribuzin nor paraquat reduced goldenrod stand adequately (Table 3). When used sequentially, these herbicides reduced the goldenrod stand by 66%. Rimsulfuron used alone at 15

Table 3. Effect of rimsulfuron applied alone, sequentially with metribuzin, or when mixed with metribuzin on narrowleaf goldenrod and quackgrass control, and on potato marketable yield.

Herbicide	Rate	Timing[a]	Goldenrod stand		Quackgrass control		Potato marketable yield	
			1993	1995	1993	1995	1993	1995
	g/ha		plants/m row		%		kg/ha	
Metribuzin	500	PRE	16.6	2.4	0	0	18,210	25,800
Paraquat	600	GC	15.7	0.6	25	21	26,240	29,300
Metribuzin	500	PRE	7.6	1	11	21	29,980	31,800
+ paraquat	600	GC						
Rimsulfuron[b]	15	four-lf	5.7	0.6	95	86	34,360	35,200
Rimsulfuron	25	four-lf	2.4	0.4	95	87	34,110	34,200
Rimsulfuron	15	four-lf	8.9	1	94	87	33,270	34,900
+ metribuzin	180	four-lf						
Rimsulfuron	15	four-lf	5.5	0.3	94	87	35,970	33,100
+ metribuzin	300	four-lf						
Metribuzin	500	PRE	—	0.8	—	91	—	30,900
+ rimsulfuron	15	four-lf						
Metribuzin	500	PRE	—	0.7	—	94	—	29,200
+ rimsulfuron	25	four-lf						
Nontreated	—		23.3	3.7	0	0	15,970	14,500
LSD (P = 0.05)			4.1	1.8	3	4	4,300	9,200

[a] Abbreviations: lf, leaf; GC, groundcrack; PRE, preemergence.

[b] Nonionic surfactant (0.2%, v/v) added to all rimsulfuron treatments.

Table 4. Effect of rimsulfuron alone or mixed with metribuzin on potato cultivar foliar injury and marketable yield (means of 2 yr).

Treatment	Rate	Foliar injury[a]			Marketable yield		
		Russet Burbank	Kennebec	Shepody	Russet Burbank	Kennebec	Shepody
	g/ha	%			kg/ha		
Rimsulfuron[b]	15	8	2	6	35,020	37,000	32,220
Rimsulfuron	25	7	5	7	34,260	34,580	34,080
Metribuzin + rimsulfuron	250 15	11	6	14	33,580	34,390	32,750
Metribuzin + rimsulfuron	500 15	11	8	20	33,640	36,750	31,900
Metribuzin	250	4	4	10	32,950	36,720	32,810
Metribuzin	500	6	5	12	34,280	35,790	33,950
Metribuzin-PRE[c]	500	0	0	0	35,950	37,870	32,830
Hand weeded	—	0	0	0	35,440	33,770	32,020
LSD ($P = 0.05$)		3	1	2	NS[c]	NS	NS

[a] Foliar injury visually rated at 7 d after treatment.

[b] Nonionic surfactant (0.2%, v/v) added to all rimsulfuron treatments.

[c] Abbreviations: PRE, preemergence; NS, not significant.

or 25 g/ha or tank mixed with metribuzin at 180 or 300 g/ha in 1993 reduced goldenrod stand by 62 to 90%, with no difference noted between these treatments. In 1995, the goldenrod stand was much lower and more variable, but results were comparable with 1993, with the exception of paraquat alone. Paraquat gave better stand reduction at the time of data collection, but later in the season visual observations indicated that regrowth had occurred. No differences were noted among any of the rimsulfuron alone or rimsulfuron plus metribuzin treatments.

Treatments of metribuzin, paraquat, and metribuzin plus paraquat did not provide adequate control of quackgrass (Table 3). Quackgrass control with rimsulfuron alone at 15 or 25 g/ha and with 15 g/ha rimsulfuron combined with metribuzin at 180 or 300 g/ha gave 86 to 95% control in both years. Potato marketable yield in 1993 was reduced with the metribuzin, the paraquat, and the metribuzin plus paraquat treatments, most likely because of the lack of quackgrass control and the poor control of goldenrod in 1993. In 1995, marketable yield was reduced with metribuzin alone for the same reason. All treatments containing rimsulfuron gave comparable yields that were all greater than that of the nontreated control. Tuber specific gravity was not affected by any of the treatments (data not shown).

Cultivar Response to Rimsulfuron. The three potato cultivars evaluated in this study responded differently to rimsulfuron alone, with Russet Burbank and Shepody having comparable injury and Kennebec being injured the least (Table 4). When applied as a tank mix with metribuzin, Shepody injury was increased two- to threefold, Russet Burbank injury almost twofold, and Kennebec injury twofold. Metribuzin caused no injury when used PRE, but caused 4 to 6% injury on Russet Burbank and Kennebec, and 10 to 12% injury on Shepody when used POST. Metribuzin at both rates with rimsulfuron gave comparable injury to Russet Burbank and Kennebec, but the high rate caused greater injury on Shepody. The increased foliar injury by the addition of metribuzin appears to have been additive and caused by metribuzin rather than by response to rimsulfuron. No detrimental effect on potato marketable yield was noted with rimsulfuron alone or when tank mixed with metribuzin, even though foliar injury occurred to Shepody. Tuber specific gravity was not affected by any of the treatments (data not shown). These results are similar to those noted in Idaho (Eberlein et al. 1994) and Michigan (Renner and Powell 1998), where transient injury from rimsulfuron on Russet Burbank was observed, but potato yields were not found to be affected by the treatments.

Evaluation of the sprouting ability of retained daughter tubers the next spring showed that rimsulfuron had no effect on sprouting of any of the three cultivars (data not shown). The number of sprouts per tuber and the fresh weight of the sprouts were not affected when compared with the hand-weeded control or the metribuzin-alone treatment. Application of rimsulfuron at 15 or 30 g/ha had no effect on sprout number or fresh weight of any cultivar.

Although rimsulfuron provided variable control of quackgrass because of adverse environmental conditions, it was effective in controlling corn spurry, narrowleaf goldenrod, and wild radish, which are common problem weeds on PEI. Metribuzin is commonly used for weed control in potato on PEI, but it does not control narrow-

leaf goldenrod. Metribuzin, because of its short soil residual period, does not control late-emerging wild radish plants. Sequential applications of metribuzin PRE and rimsulfuron POST provide a broader spectrum of weed control than is possible by either of them used alone. Metribuzin plus rimsulfuron POST is not registered for use in Canada, but these data suggest that this treatment is possible on Russet Burbank and Kennebec cultivars that are not susceptible to metribuzin as slight injury noted in our study had no effect on yield. Injury on Shepody, however, was more severe, and although yields were not affected statistically in these trials, there was a trend toward lower yields. More research is needed under differing climatic conditions before a recommendation to growers for the use of metribuzin plus rimsulfuron can be made.

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